should be at least as big as Ireland. It is true, no doubt, that small planets would be fitted for the residence of large beings, and large planets would be proper for small beings. The Lilliputians might be sought for on a globe like *Jupiter*, and the Brobdingnagians on a globe like *Mars*, and not *vice versâ*, as might be hastily supposed. But no Brobdingnagian's arms would be mighty enough to wave the flag on *Mars* which we should be able to see here. No building that we could raise, even were it a hundred times more massive than the Great Pyramid, would be discernible by the *Martian* astronomer, even had he the keenest eyes and the most potent telescopes of which our experience has given us any conception.

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## THE SUN'S MOTION IN SPACE.—III.*

By W. H. S. Monck.

Some time ago I communicated to this Society a simple mode of estimating the sun's motion in space, which I believed to be sufficiently accurate until we possess more reliable data than at present. I lately applied this method to Professor Porter's Catalogue of 301 stars, with proper motion of half a second or upwards, which appeared in *The Astronomical Journal* for June 13, 1892. I found that on seeking to divide the stars in respect of R. A. into two equal parts, one of which should contain the maximum amount of increasing and the other of diminishing Right Ascensions, the best divisions were from $7^h$ to $19^h$ and from $19^h$ to $7^h$, thus fixing the Right Ascension of the sun's goal at $285^\circ$ (for the epoch 1900). The results were as follows:

| | Stars with motions in Increasing R. A. | Stars with motions in Diminishing R. A. | Stars with No motion in R. A. |
|---|---|---|---|
| $7^h$ to $19^h$ | 37 | 103 | 3 |
| $19^h$ to $7^h$ | 118 | 39 | 1 |

Dividing the stars with no motion in R. A. equally between + and —, and assuming that if the sun were motionless the proper motions in increasing and diminishing R. A. would be equal for both divisions, the result for $19^h$ to $7^h$ makes the sun's motion in R. A. exactly equal to the average motion of the stars, having

* See *Publications A. S. P.*, Vol. IV., page 70.

converted exactly one-half of the really diminishing motions into increasing motions. But for the division $7^h$ to $19^h$ the effect of the sun's motion is only 92 per cent. of the average motion of the stars. We may adopt 96 per cent. as the mean of the two.

In respect of N. P. D., 210 stars gave a receding motion, 84 an approaching motion, and 7 were motionless. Adopting the same course here, the effect of the sun's motion in N. P. D. is only 72 per cent. of the average motion of the stars. Assuming that the average motion of the 301 stars is the same in Declination as in Right Ascension (or, rather, in parallel), we get for declination of the sun's goal, $\tan \delta = \frac{72}{96} = \frac{3}{4}$; whence $\delta = 37^\circ$ nearly.

Professor PORTER does not deduce the sun's motion from these 301 stars, the divisions which he used being as follows: (1) 70 stars with motion of $1''.20$ annually; (2) 142 stars with motion of $0''.60$ to $1''.20$; (3) 533 stars with motion of $0''.30$ to $0''.60$; and (4) 576 stars with motion of $0''.15$ to $0''.30$. Of the 301 stars in question, 212 are included in the first two of these divisions and 89 in the third. The positions of the sun's goal obtained from his first three divisions are respectively $277^\circ.0$, $+ 34^\circ.9$, $285^\circ.2$, $+ 34^\circ.0$, and $280^\circ.7$, $+ 40^\circ.1$, all which, it will be seen, agree very fairly with my rough computation of $285^\circ$, $+ 37^\circ$. The sun's velocity in space could be estimated from these data if we knew the average velocity of the stars. VOGEL estimates the average velocity of the stars in the line of sight at 10.4 miles per second. Stars specially selected for their large proper motions may be expected to average more than this in R. A. and Decl. An average velocity of 12.5 miles per second in R. A. and Decl. for these stars would give a total velocity of about 15 miles per second for the sun.

Further consideration, however, qualifies these results. It seems now the general opinion of astronomers that the Milky Way consists of a cluster or system of stars chiefly of the *Sirian* type, while the solar stars, whose distribution over the sky is pretty uniform, chiefly belong to a different system. If this be so, we may expect a different goal when we employ *Sirian* and solar stars respectively. But stars with large proper motion, such as those used by Professor PORTER, are chiefly solar. In this Catalogue of 301 stars I succeeded in identifying 107 stars in the *Draper Catalogue*, of which only 9 had spectra of the *Sirian* type, while there were 97 solars. The goal thus determined can

differ very little from one determined by using solar stars only. And the same remark is partially applicable to the whole of the *Cincinnati Catalogue* used by Professor PORTER, and containing 1340 stars. In this Catalogue I only succeeded in identifying the spectra of 87 *Sirian* stars against 385 solars. When we employ stars with large proper motion to determine the sun's goal, it is plain that we are giving undue weight to solar stars and assigning too little weight to the Galaxy, if it really forms a separate system.

When we employ stars with small proper motion, on the other hand, our results are largely affected by errors, whether systematic or casual. That casual errors may effect the result can be thus shown: Suppose that the chance of changing a + into a — is, in the case of any given star, equal to that of changing a — into +, it is clear that if the plusses are in reality three times as numerous as the minuses, three times as many of them will be transferred to the minus side as there will be minuses transferred to the plus side. Casual errors will thus tend to equalize the number of stars on both sides, and thus to mask the effect of the sun's motion. But it seems to be conceded that errors occur more frequently in Right Ascension than in Declination. Hence, if we use stars with small proper motion, the equalizing process will be carried farther in Right Ascension than in Declination. The effect of the sun's motion in Declination will appear more clearly because it is less masked, and the result will be that a more northerly position will be obtained for the sun's goal.

The *Cincinnati Catalogue* confirms this conclusion in an unexpected way. Large proper motion is, of course, more likely to be attained when the effect of the sun's motion is additive than when it is subtractive. The motion of the sun towards the north pole makes the stars seem to move away from it, and a star which is really moving away from it is more likely to exhibit large proper motion in N. P. D. than one which is approaching. Now, on account of the uncertainties affecting motion in R. A., Professor PORTER adopted a higher limit for motion in R. A. than for motion in N. P. D. in his Catalogue—the one being practically $0''.225$ and the other $0''.150$. The result is that the *Cincinnati Catalogue*, taken as a whole, makes the effect of the sun's motion in N. P. D. greater than any other Catalogue that I have examined. Here are the results in R. A. and N. P. D. respectively ($7^h$ and $19^h$ seem again the best divisions in R. A.):

| | RIGHT ASCENSION. | | |
|---|---|---|---|
| | Increasing R. A. | Diminishing R. A. | No motion. |
| $7^h$ to $19^h$ | 179 | 437 | 34 |
| $19^h$ to $7^h$ | 439 | 207 | 44 |

North Polar Distance—receding 1002, approaching 302, no motion 36.

Treating this by my method, the position of the goal comes out at about 285°, + 55°; but I have little doubt that this high northerly Declination is merely owing to the fact that the Catalogue contains an undue preponderance of stars with large proper motion in N. P. D. This preponderance chiefly occurs in the fourth of Professor PORTER'S divisions, for which his goal is 281°.9, + 53°.7. If he would extend his Catalogue so as to make the inferior limit in R. A. $0^s.01 \cdot \cos \delta$ instead of $0^s.015 \cdot \cos \delta$, I suspect the position of his goal for this division would be found to have moved several degrees to the south. We must be impartial as regards motion in R. A. and in Declination if we mean to arrive at satisfactory results. The greater liability of the former to errors may to a certain extent mask the effect of the sun's motion, but the masking is much greater when we omit stars with considerable motion in R. A. altogether. In fact, the R. A. as well as the Declination of every star in the Catalogue, is used in the computation. The majority of the stars introduced on account of their large motions in R. A. have comparatively small declinations, and *vice versâ*. The more stress, therefore, we lay upon large proper motions in Declination, the greater will be the proportion of small motions in R. A., with which we shall have to deal; and it is these small motions which are specially liable to error and to consequent masking of the sun's effect. It would, in fact, be better to adopt a lower limit in Right Ascension than in Declination in framing such a Catalogue, because the movements in R. A. with which we were dealing would, in that case, average more than the motions in Declination, and the effect of errors in the two cases would thus be more nearly equalized.

A determination of the sun's goal, using *Sirian* stars only for the purpose, would be worth making. A rough estimate from the stars in the *Cincinnati Catalogue* which I succeeded in identifying as *Sirian* makes the Northern Declination very small. But there is a strange peculiarity as regards the proper motion of these stars in N. P. D. In the first 12 hours of R. A. the excess of stars receding from the north pole is very great, but in the last

12 hours the majority of the *Sirian* stars are actually approaching the pole. Assuming the *Sirian* stars to be Galactic, this effect is exactly what would be produced by a revolution of the great Galactic ring, whose greatest northern and southern extensions are not far from $0^h$ and $12^h$ in Right Ascension.* The Galactic stars are thus moving to the N. in Aquila and to the S. in Taurus. The number of stars used (especially considering the manner in which the Catalogue has been compiled) is not sufficient to warrant a positive conclusion, but this seems to me to be the direction in which the evidence points. Of course, if such a revolution exists, the Galactic stars are not moving indifferently in all directions, and the motion of the Galaxy will have to be ascertained and allowed for in ascertaining the sun's goal with respect to it.

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## PHYSICAL OBSERVATIONS OF *JUPITER'S* SATELLITES IN TRANSIT.

By John Tebbutt, F. R. A. S.

The following notes on the physical appearances of *Jupiter's* satellites during transit have been condensed from the records in my observatory journal, and may prove interesting in connection with the communications already appearing from me in Vol. III of the *Publications of the Astronomical Society of the Pacific*, No. 16, page 221, and No. 19, page 353. The times given are local sidereal:

*Transit of Satellite II, September 12, 1891.*—The internal contact at ingress occurred at $18^h\ 33^m\ 21^s$. The satellite continued visible as a bright spot till $18^h\ 46^m$. It had ceased to be visible at $18^h\ 48^m\ 45^s$. Although the planet's disc was at intervals carefully examined, no further trace of the satellite could be seen till near the time of egress, when it again became visible as a bright spot. The observations were made with powers of 120 and 180 on the 4½-inch equatorial.

*Transit of Satellite III, October 2, 1891.*—The early part of this transit occurred during sunlight. At $19^h\ 6^m\ 13^s$ the satellite

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* Taking the poles of the Galaxy as $0^h\ 50^m$ and $12^h\ 50^m$, I find 22 *Sirian* stars between $12^h\ 50^m$ and $0^h\ 50^m$ with approaching motion against 16 receding. The sun's goal deduced from the motions of these 38 stars would probably have a Southern Declination.